John Giessner

From: John Ellegood
Sent: Wednesday, July 16, 2008 8:56 AM
To: Mahesh Chawla; Ross Telson; Christine Lipa; John Giessner; Ross Telson; Christine Lipa; Robert Lerch; Frank Tran; Thomas Taylor; Kent Wood
Subject: RE: Palisades SFP racks
Attachments: nus-assess.doc; sfpcell.pdf

Release

I have attached the earlier analysis done by Entergy to determine the effects of absorber loss on Keff. In addition, I attached the results from the first panel of the first cell. Data has been collected from 4 or 5 more panels but the data has not been analyzed. Based on the shape of the curves, the licensee believes those panels will fail as well.

From: Mahesh Chawla
Sent: Wednesday, July 16, 2008 9:23 AM
To: Ross Telson; Christine Lipa; John Giessner; John Ellegood; Ross Telson; Christine Lipa; Robert Lerch; Frank Tran; Thomas Taylor
Subject: FW: Palisades SFP racks

FYI

NRR-Release

From: Lambros Lois
Sent: Wednesday, July 16, 2008 8:48 AM
To: Mahesh Chawla
Cc: Gregory Cranston; Kent Wood
Subject: RE: Palisades SFP racks

Mahesh:
Kent Wood of SRXB is in charge of SFPs and he has this project. I'm forwarding this to Kent.
Lambros Lois.

From: Mahesh Chawla
Sent: Wednesday, July 16, 2008 8:30 AM
To: Lambros Lois
Cc: John Giessner; John Ellegood; Ross Telson; Christine Lipa; Robert Lerch; Frank Tran; Thomas Taylor
Subject: FW: Palisades SFP racks

Lambros,

Let me know if you need more information or discussion on this issue. Thanks

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From: John Ellegood
Sent: Wednesday, July 16, 2008 7:25 AM
To: Ross Telson; Christine Lipa; Mahesh Chawla
Cc: John Giessner; Robert Lerch; Frank Tran; Thomas Taylor
Subject: Palisades SFP racks

Release

The licensee has some preliminary results from the BADGER testing of the SFP racks. The first panel did not meet the density requirements. The data from the next four panels is in analysis but the preliminary evil indicates they will not pass.

The licensee has an analysis that shows Keff is less than .95 with no credit for the racks provided SFP boron is above 2054. It is at 2732.

C.83

I'll keep you posted.

Mac- do you who we spoke with on the SFP swelling rack issue?

John Ellegood

Release

Report on Resolution of Outstanding Concerns on Spent Fuel Pit Rack Localized Swelling Palisades Nuclear Plant

SUBJECT

This report addresses concerns raised by the NRC on the reliability of the Palisades Spent Fuel Pit (SFP) Region I storage racks to maintain fuel in a subcritical condition in accordance with the original rack design as identified in Technical Specification (TS) Section 4.3.1, and in consideration of the effects of potential neutron absorber localized degradation.

SUMMARY OF CONCLUSIONS

Based on a review of Palisades reports and observations made to date, and as corroborated by rack surveillance evidence elsewhere in the industry, reasonable assurance exists to support the position that the neutron absorber has not degraded in the Region I racks. Furthermore, an internal Entergy assessment provides reasonable assurance that, even if the neutron absorber were to be completely degraded, the 1R19 boron concentration in the SFP cooling water would more than compensate for any possible loss of reactivity holddown.

BACKGROUND

Fuel assembly binding in Region I of the Palisades SFP has been observed since 1991 (Reference 1). This binding has been attributed to localized swelling of the Region I SFP racks due to gas buildup within the rack structure. In 1995, Palisades performed a re-evaluation (Reference 2) to update and more fully document the analyses associated with the localized rack swelling. As of this writing there are ten (10) fuel assemblies that cannot be extracted from the Region I racks due to localized swelling.

Since the affected assemblies are generally in isolated rack locations, with only two in adjacent cells, it is possible to access these cells for testing or venting of the buildup gas, once the surrounding fuel assemblies have been removed. The SFP is completely filled at the present time. Therefore, repair activities are not possible until completion of the next dry cask storage program at Palisades, currently scheduled for spring 2008.

An additional concern regarding future repair work is the caution associated with cutting or grinding in the vicinity of a trapped pocket of hydrogen gas, even under water. Entergy is reviewing possible approaches to rack maintenance and repair that should minimize risk of inadvertent combustion, but, again, this emphasizes the position that adjacent cells must be empty in order to take action to vent the trapped gas.

The NRC has voiced concern that the affected Palisades rack cells may be experiencing degradation of neutron holddown, due to potential leakage or slumping of the boron carbide (B4C) neutron absorber within the swollen rack areas. As described in the sections that follow, Entergy has reviewed the engineering bases for the racks and performed a criticality assessment to determine the potential impact of absorber degradation.

REVIEW OF RACK ENGINEERING BASES

An extensive evaluation was completed by Palisades in support of the Condition Report evaluated in Reference 2. This included input from the B4C manufacturer, the Carborundum Company. Some of the general conclusions of the report are:

- There was visible evidence of an unidentified black material leaching through the vent holes. This could represent a small loss of B4C material. However, because the vent holes are near the tops of the cells and the amount of observed material is small, the impact of any B4C material loss is expected to be very slight.

- The Carborundum Co has reviewed the data (as reported in Reference 3) and concluded that the black material is very likely a boron compound but notes that boron leachability over time is relatively low , although there is no test data to document leaching over a 10-15 year time span.

- There are no vent holes at the base of the racks. Thus, a slow discharge of degraded B4C material, with its inherent loss of reactivity holddown, is not considered a credible scenario.

In addition, interviews with Engineering personnel confirm that the actual locations of the vent holes are below the tie plate, but slightly above the active core height. Therefore, if the all the interior B4C above the vent were to leak through the holes, there would be an insignificant amount of reactivity holddown degradation in the active fuel region.

Because Palisades does not have rack material surveillance coupons, Palisades has requested supporting information from the Kewaunee plant, which uses a similar B4C rack design and which has an active surveillance plan. Kewaunee responded (Reference 4) by stating that other than some possible B4C dust leakage and some observed chipping (most likely due to the effects of handling), there was no visible degradation of the B4C material. However, as Kewaunee does not test for brittleness, they were unable to confirm that B4C would not degrade under long-term temperature and radiation exposure. Therefore, it reasonable and conservative to assume at least some degree of B4C degradation over time.

As noted above, there are no vent holes at the rack base to permit egress of degraded B4C. As the majority of the racks remain in their original configuration, we can conclude that, except for the swollen racks, the B4C remains in place. For the swollen rack locations, it is conceivable to consider a B4C "slumping" effect, in which the degraded neutron absorber, now in powdered form, sinks to a lower level inside the racks, as would a liquid. Realistically, the maximum amount of slumping would reduce the absorber height to no lower than approximately 80% of its original position.

However, because slumping to that degree could remove neutron absorber function in the very top of the affected rack locations, Entergy has elected to perform a criticality assessment, considering the potential for B4C loss and crediting SFP boron concentration to compensate.

CRITICALITY ASSESSMENT

In order to provide assurance that k-effective was remaining within the limits of design basis assumptions, Entergy has completed a criticality assessment, with SFP boron concentration credited for reactivity holddown in lieu of B4C. Although the criticality analysis of record (AOR) takes no credit for SFP boron in the Region I rack area, the assessment provides assurance that a k-effective below 0.95 will be maintained until such time as rack repairs may be performed.

The criticality analysis was prepared using the existing model of the Palisades Region I racks from the AOR (Reference 5). Note well: The MONK computer code, used previously for the criticality analysis, is no longer available. Therefore, the racks were modeled using the CASMO series of modeling codes (Reference 6), which are compatible with the rack model used by MONK. CASMO-4 was used for the calculated criticality values, with an independent check on CASMO-3 for each Eigenvalue. However, Entergy is **not** licensed to use CASMO for design basis calculations: therefore, the results that follow must be considered as an assessment, suitable for operability determination, rather than a formal calculation.

Assumptions associated with the criticality assessment are as follows:

- The model assumes the entire Region 1 is filled with new fuel enriched to 4.95 w/o U-235, as noted in Technical Specification 4.3.1 (Reference 7);

- The model takes no credit for B4C reactivity holddown. In other words, it assumes complete degradation of <u>all</u> neutron absorber and its replacement in the gap by B4C off-gas. This is an <u>extremely</u> conservative position, but is retained as it (1) provides a more straightforward model and (2) bounds the current conditions;

- Because the U-235 enrichment is a nominal one, several cases were repeated for an actual enrichment of 5.00 w/o, which is the nominal value of 4.95 w/o U-235 plus a manufacturing uncertainty of 0.05 w/o;.

- In order to establish the most conservative conditions, an additional case was run with the gap filled with water instead of gas.

The code was run for a variety of SFP boron concentrations. The most significant of these are 1720 ppm, which is the minimum SFP boron concentration required by the Palisades Technical Specification 3.7.15 (Reference 8) and 2550 ppm, which is the 1R19 refueling boron concentration. 2550 ppm is also a procedural minimum (Reference 9) for normal operation in Modes 1-4, required to ensure core subcriticality after a design basis seismic event. For normal operation in Modes 5 and 6, a procedural minimum SFP boron concentration of 1800 ppm is specified.

With these considerations in mind, the results of the criticality assessment are as follows Results are in units of k-inf, which is criticality in infinite array, and bounds (i.e. is always greater than) k-effective:

1. The k-inf for Region 1, crediting a 1720 ppm boron concentration in the SFP, is below 0.98.

2. The k-inf for Region 1, crediting an 1800 ppm boron concentration in the SFP, is below 0.98.

3. The k-inf for Region 1, crediting a 2550 ppm boron concentration in the SFP, is below 0.92.

4. The SFP boron concentration corresponding to a k-inf of 0.95 is approximately 2054 ppm.

5. These conclusions remain valid if the gas within the rack is replaced by unborated water.

6. Increasing enrichment from 4.95 w/o to 5.00 w/o U-235 results in a slight increase in k-inf, across a range of 0.0015 to 0.0027.

Therefore, based on the engineering review and criticality assessments described above, it is reasonable to conclude that B4C degradation, in the Region 1 affected areas, is likely to be very slight. However, any degree of degradation, up to and including complete loss of neutron absorber, is not expected to result in an increase of k-effective above 0.95 while the SFP boron concentration remains at or above the procedural minimum of 2550 ppm.

Written by: ______________________________

Reviewed by: ____________________________

REFERENCES

1. Palisades Deviation Report D-PAL-91-015H

2. Palisades Condition Report C-PAL-95-0343

3. Consumers Power Co Memorandum SEL94*008, Lucier to Krueger, "NUS Spent Fuel Pool Rack Boron Carbide Neutron Absorber Information," 6/13/94

4. E-Mail from Jeffery Ladewig (Kewaunee) to G. T. Wiggins (Palisades) 9/19/07

5. Palisades Calculation EA-SFP-97-02, "Region I Fuel Pool Criticality Calculations," 3/27/00

6. Computer codes CASMO-4 and CASMO-3

7. Palisades Technical Specification 4.3

8. Palisades Technical Specification 3.7.15

9. Palisades Procedures COP-27, COP-27-Basis, SOP-27, SFPO-3, DWC-11D, DWC-11D-Basis, PCSO-5, GOP-2

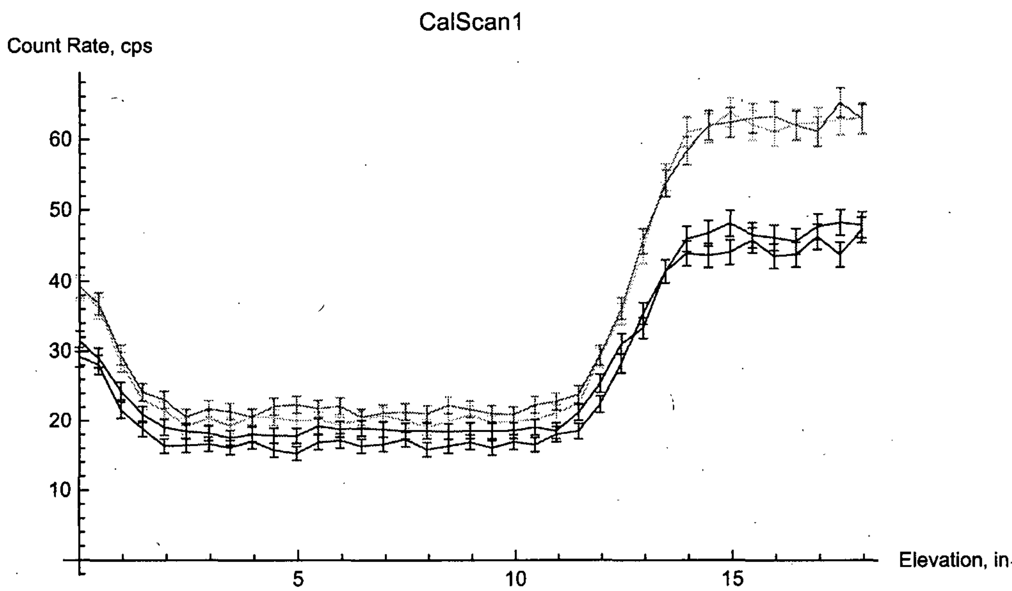
Pallisades Initial Data Analysis

Qualitative Analysis

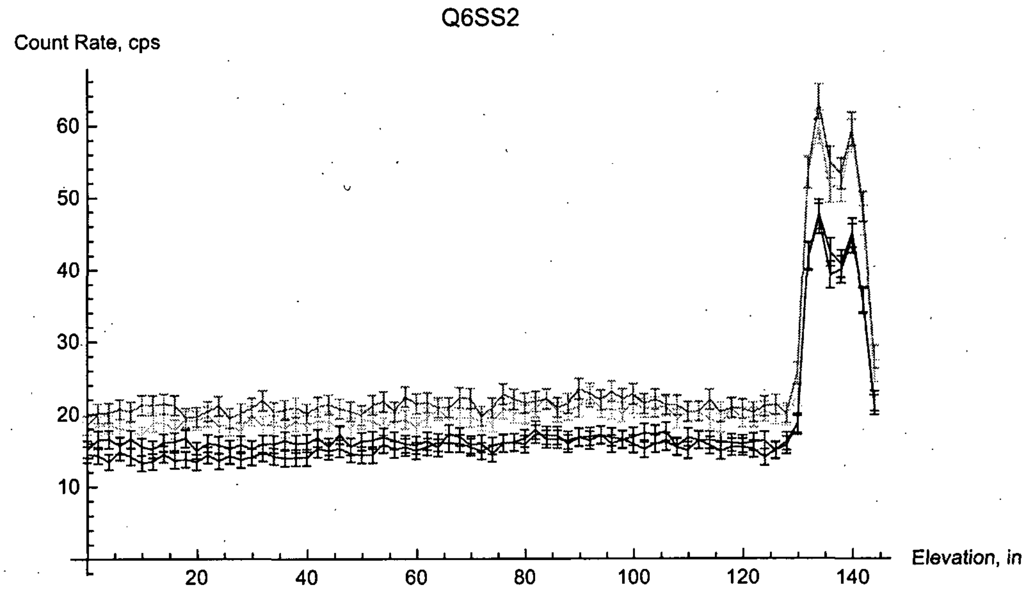
The following analysis shows the comparison of the calibration scan data with the first scan for the Pallisades neutron absorber test. Preliminary analysis shows that, for the first panel scanned, we must reject the hypothesis that this panel meets the minimum certified areal density value with 95% certainty.

For the individual elevation count rates, the uncertainty is Calculated as $\pm \frac{2\sigma}{t}$ where $\sigma \equiv \sqrt{\text{Counts}}$ and $t \equiv$ Count Time. This bounds the count rate with 95% certainty based upon the counts having a poisson distribution. Count Time uncertainty is less than 10^{-6} sec and, as such, is neglected.

The following plot shows the calibration scan count rates as a function of elevation for all 4 detectors.

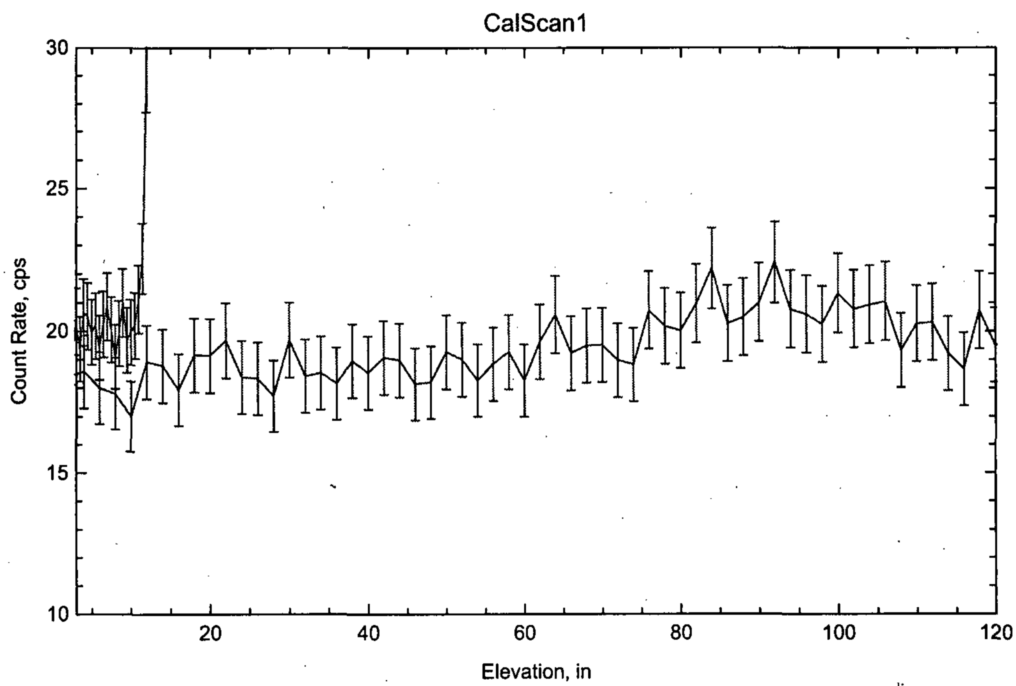


This plot can be compared with the first panel scanned, "Q6 South".



Both scans appear to have similar count rates in the absorber panel region. However, upon further examination, it can be shown that panel "Q6 South" may show a lower areal density (higher count rate) than the calibration cell which is manufactured at the minimum certified areal density value.

The following plot shows the calibration scan (in blue) for detector-2 overlaid upon the scan of panel Q6 South (in red) for the same detector. To exceed the minimum certified areal density value, we would expect that the average maximum count rate (minimum areal density) in the test panel should be less than the average minimum count rate (maximum areal density) in the calibration cell. For regions around 90" elevation, this is clearly not the case.



Statistical Analysis

A more quantitative analysis can be performed by examining the average minimum and average maximum count rates for the calibration cell and test cell respectively.

Calibration Cell

Selecting data from the panel region of the calibration cell (between 3" and 10" elevation) shows the average minimum count rate and the associated standard deviation.

The following data shows the raw scan data for detector 2. Uncertainty is calculated as specified previously. Data is in the format "{Elevation, Count Rate, Count Rate Uncertainty}"

3.451	19.3667	1.13627
3.946	20.65	1.17331
4.442	20.5167	1.16952
4.956	19.9667	1.15374
5.451	20.1833	1.15998
5.947	19.4167	1.13774
6.443	20.2333	1.16142
6.938	20.85	1.17898
7.452	20.05	1.15614
7.948	19.1	1.12842
8.443	19.9167	1.15229
8.939	20.9833	1.18275
9.453	19.6833	1.14552
9.948	19.9667	1.15374

The average minimum count rate for detector-2 in the calibration cell scan is calculated from the above data.

Average Minimum Count Rate:

$$\frac{1}{n}\sum_{i=1}^{n}\left(\text{CountRate}_i - \text{CountRateUncertainty}_i\right) =$$

18.9067

At a minimum, we would expect that a test panel count rate should not go above this value to be assured of conformance with the minimum certified areal density. Note that this does not take into account the standard deviation associated with the above calculation (shown below).

Minimum Count Rate Standard Deviation:

$$\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\left(\text{CountRate}_i - \text{CountRateUncertainty}_i\right) - \text{AverageMinimumCountRate}\right)^2} =$$

0.543706

Test Panel "Q6 South"

Selecting data from the panel region of the "Q62S" test cell (between 3" and 120" elevation) shows the average maximum count rate and the associated standard deviation.

The following data shows the raw scan data for detector 2. Uncertainty is calculated as specified previously. Data is in the format "{Elevation, Count Rate, Count Rate Uncertainty}"

3.946	18.5778	1.28505
5.947	18.	1.26491
7.948	17.8	1.25786
9.948	17.	1.22927
11.949	18.9111	1.29653
13.95	18.7778	1.29195
15.95	17.9333	1.26257
17.951	19.1556	1.30488
19.952	19.1333	1.30412
21.952	19.6667	1.32218
23.953	18.3778	1.27812
25.954	18.3333	1.27657
27.954	17.7111	1.25472
29.955	19.6889	1.32292
31.956	18.4222	1.27966
33.938	18.5333	1.28351
35.939	18.1556	1.27036
37.939	18.9556	1.29805
39.94	18.5333	1.28351
41.941	19.0667	1.30185
43.941	18.9778	1.29881
45.942	18.1333	1.26959
47.943	18.2	1.27192
49.943	19.2667	1.30866
51.944	19.	1.29957
53.945	18.2667	1.27425
55.945	18.8444	1.29424
57.946	19.2667	1.30866
59.947	18.2667	1.27425
61.947	19.6222	1.32068
63.948	20.5778	1.35246
65.949	19.2222	1.30715
67.949	19.4889	1.31619
69.95	19.5111	1.31694
71.951	18.9778	1.29881
73.951	18.8222	1.29348
75.952	20.7333	1.35756
77.953	20.1778	1.33925
79.953	20.0222	1.33407
81.954	20.9556	1.36481
83.955	22.2	1.40475
85.955	20.2667	1.34219

87.938	20.4889	1.34953
89.938	21.	1.36626
91.939	22.4	1.41107
93.94	20.7778	1.35901
95.94	20.6	1.35319
97.941	20.2444	1.34146
99.942	21.3333	1.37706
101.942	20.7778	1.35901
103.943	20.9333	1.36409
105.944	21.0444	1.36771
107.944	19.3333	1.31092
109.945	20.2667	1.34219
111.946	20.3111	1.34366
113.946	19.2222	1.30715
115.947	18.6667	1.28812
117.948	20.7333	1.35756
119.948	19.5111	1.31694

The average maximum count rate for detector-2 in the test cell scan is calculated from the above data.

Average Maximum Count Rate:

$$\frac{1}{n}\sum_{i=1}^{n}\left(\text{CountRate}_i + \text{CountRateUncertainty}_i\right) =$$

20.7578

This value exceeds the average minimum count rate associated with the calibration cell as established above. Thus, we must reject the hypothesis that the test panel exceeds the areal density of the calibration panel which is at the minimum certified areal density.

For reference, the standard deviaiton of the maximum test cell count rate is calculated below.

Maximum Count Rate Standard Deviation:

$$\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\left(\text{CountRate}_i + \text{CountRateUncertainty}_i\right) - \text{AverageMaximumCountRate}\right)^2} =$$

1.11177

Reference Material

Calibration Cell Data

Palisades 2008 07/14/08,M. Harris,,
0,18,36,60
7/14/2008,10:55 AM,,
0.000,1749.000,2329.000,2355.000,1884.000
0.441,1689.000,2173.000,2211.000,1748.000
0.954,1295.000,1711.000,1769.000,1461.000
1.450,1131.000,1379.000,1450.000,1257.000
1.946,981.000,1297.000,1385.000,1144.000
2.441,987.000,1155.000,1234.000,1110.000
2.955,996.000,1220.000,1306.000,1093.000
3.451,970.000,1162.000,1285.000,1055.000
3.946,1023.000,1239.000,1236.000,1083.000
4.442,945.000,1231.000,1328.000,1074.000
4.956,916.000,1198.000,1343.000,1070.000
5.451,1014.000,1211.000,1309.000,1154.000
5.947,1029.000,1165.000,1329.000,1126.000
6.443,984.000,1214.000,1236.000,1138.000
6.938,998.000,1251.000,1271.000,1128.000
7.452,1041.000,1203.000,1281.000,1113.000
7.948,952.000,1146.000,1265.000,1113.000
8.443,981.000,1195.000,1337.000,1108.000
8.939,1015.000,1259.000,1303.000,1115.000
9.453,966.000,1181.000,1265.000,1112.000
9.948,1017.000,1198.000,1254.000,1116.000
10.444,993.000,1212.000,1340.000,1145.000
10.939,1083.000,1267.000,1369.000,1112.000
11.453,1111.000,1353.000,1430.000,1272.000
11.949,1346.000,1745.000,1766.000,1527.000
12.445,1701.000,2122.000,2171.000,1867.000
12.940,2126.000,2660.000,2741.000,2000.000
13.454,2487.000,3284.000,3230.000,2488.000
13.950,2761.000,3665.000,3508.000,2640.000
14.445,2808.000,3698.000,3720.000,2623.000
14.941,2890.000,3824.000,3742.000,2649.000
15.455,2795.000,3722.000,3780.000,2752.000
15.950,2773.000,3668.000,3795.000,2619.000
16.446,2742.000,3731.000,3718.000,2632.000
16.941,2864.000,3743.000,3670.000,2781.000
17.455,2900.000,3766.000,3910.000,2633.000
17.951,2879.000,3783.000,3772.000,2838.000

Panel "Q6 South" Data

Palisades 2008 07/14/08,M. Harris,,
0,144,72,45
7/14/2008,2:00 PM,,
0.000,650.000,795.000,831.000,683.000
1.946,645.000,828.000,905.000,742.000
3.946,605.000,836.000,908.000,744.000
5.947,667.000,810.000,930.000,706.000
7.948,636.000,801.000,915.000,747.000
9.948,596.000,765.000,956.000,698.000
11.949,606.000,851.000,955.000,682.000
13.950,652.000,845.000,963.000,724.000
15.950,613.000,807.000,956.000,730.000
17.951,619.000,862.000,878.000,751.000
19.952,603.000,861.000,883.000,675.000
21.952,646.000,885.000,918.000,719.000
23.953,610.000,827.000,950.000,709.000
25.954,642.000,825.000,875.000,685.000
27.954,617.000,797.000,904.000,711.000
29.955,635.000,886.000,939.000,683.000
31.956,659.000,829.000,984.000,715.000
33.938,639.000,834.000,914.000,716.000
35.939,628.000,817.000,928.000,738.000
37.939,631.000,853.000,943.000,718.000
39.940,633.000,834.000,904.000,722.000
41.941,686.000,858.000,947.000,754.000
43.941,673.000,854.000,960.000,701.000
45.942,688.000,816.000,935.000,773.000
47.943,655.000,819.000,918.000,701.000
49.943,649.000,867.000,895.000,732.000
51.944,649.000,855.000,958.000,740.000
53.945,715.000,822.000,978.000,759.000
55.945,681.000,848.000,916.000,737.000
57.946,696.000,867.000,1009.000,715.000
59.947,674.000,822.000,964.000,709.000
61.947,698.000,883.000,972.000,734.000
63.948,725.000,926.000,941.000,693.000
65.949,720.000,865.000,942.000,779.000
67.949,720.000,877.000,1003.000,759.000
69.950,696.000,878.000,998.000,711.000
71.951,671.000,854.000,888.000,717.000
73.951,705.000,847.000,938.000,656.000
75.952,722.000,933.000,1025.000,720.000
77.953,725.000,908.000,992.000,726.000
79.953,714.000,901.000,969.000,751.000

81.954,777.000,943.000,980.000,801.000
83.955,769.000,999.000,994.000,745.000
85.955,767.000,912.000,941.000,744.000
87.938,718.000,922.000,966.000,738.000
89.938,756.000,945.000,1057.000,757.000
91.939,761.000,1008.000,1028.000,738.000
93.940,772.000,935.000,988.000,769.000
95.940,718.000,927.000,1042.000,757.000
97.941,741.000,911.000,995.000,745.000
99.942,761.000,960.000,1025.000,716.000
101.942,784.000,935.000,964.000,684.000
103.943,775.000,942.000,993.000,717.000
105.944,792.000,947.000,958.000,729.000
107.944,700.000,870.000,956.000,695.000
109.945,757.000,912.000,916.000,675.000
111.946,737.000,914.000,918.000,740.000
113.946,739.000,865.000,991.000,706.000
115.947,730.000,840.000,911.000,671.000
117.948,722.000,933.000,940.000,696.000
119.948,716.000,878.000,932.000,696.000
121.949,728.000,878.000,911.000,683.000
123.950,737.000,916.000,949.000,633.000
125.950,673.000,897.000,959.000,677.000
127.951,732.000,890.000,904.000,707.000
129.952,831.000,1014.000,1154.000,842.000
131.952,1882.000,2414.000,2405.000,1889.000
133.953,2118.000,2690.000,2843.000,2145.000
135.954,1768.000,2313.000,2469.000,1909.000
137.954,1804.000,2320.000,2401.000,1840.000
139.955,1997.000,2636.000,2677.000,2031.000
141.956,1613.000,2108.000,2194.000,1604.000
143.938,983.000,1168.000,1257.000,958.000